Montana Department of
ENVIRONMENTAL QUALITY

MEMO

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**To:** Tina Laidlaw, U.S. Environmental Protection Agency Region VIII

**CC:** Bob Bukantis, Head, Water Quality Standards Section

**From:** Michael Suplee, Ph.D.

**Date:** April 2, 2009

**RE:** Application of Draft Nutrient Criteria for Montana wadeable rivers and streams

The Montana Department of Environmental Quality (MT DEQ) Standards Section has outlined its overall approach for deriving numeric nutrient criteria that protect beneficial uses in a peer-review technical document (Suplee *et al.*, 2008), available on the World Wide Web at:

**http://www.deq.state.mt.us/wqinfo/Standards/NumericNutrientCriteria.asp**.

MT DEQ is using Omernik ecoregions (level III and IV)(Woods *et al*., 2002) to segregate nutrient criteria zones across the state. The nutrient criteria and benthic algae recommendations for different level III ecoregions are shown in Table 1 below, per Suplee *et al*. (2008). In addition to the level III ecoregions shown, we estimate that about ten level-IV ecoregions will have stand-alone criteria as well. Analyses completed since Suplee *et al.* (2008) was released continue to support the approach described in the document, although more recent work shows that some ecoregional criteria could be less stringent (Canadian Rockies TP criteria can be raised to 0.011 mg TP/L, 0.227 mg TN/L, and 0.062 mg $NO_{2+3}$/L) while some ecoregional criteria should be slightly more stringent (e.g., Middle Rockies TP should be closer to 0.03 mg/L). These refinements are based on additional stressor-response work from the Canadian Rockies, and from a review of other peer-review scientific literature. All other aspects of the criteria (period of application, algae levels) remain the same. If a downstream lake is involved, year round loading considerations to the lake will likely apply, and may alter the concentration limits shown. (This would likely be determined within a TMDL.) However, this memo only addresses criteria for stream protection. Please note that these are still draft criteria; the final criteria will be released in a DEQ circular that will have to be approved by the Montana Board of Environmental Review.

Table 1. Draft Numeric Nutrient and Benthic Algae Criteria for Different Ecoregions of Montana.

| Level III Ecoregion | Period When Criteria Apply | Nutrient Criteria | | | Benthic Algae Criteria |
|---|---|---|---|---|---|
| | | Total P (mg/L) | Total N (mg/L) | $NO_{2+3}$ (mg/L) | |
| Northern Rockies | July 1 -Sept. 30 | 0.012 | 0.233 | 0.081 | 150 mg Chl *a*/$m^2$ (36 g AFDW/$m^2$) |
| Canadian Rockies | July 1 -Sept. 30 | 0.006 | 0.209 | 0.020 | 150 mg Chl *a*/$m^2$ (36 g AFDW/$m^2$) |
| Middle Rockies | July 1 -Sept. 30 | 0.048 | 0.320 | 0.100 | 150 mg Chl *a*/$m^2$ (36 g AFDW/$m^2$) |
| Idaho Batholith | July 1 -Sept. 30 | 0.011 | 0.130 | 0.049 | 150 mg Chl *a*/$m^2$ (36 g AFDW/$m^2$) |
| Northwestern Glaciated Plains* | June 16-Sept. 30 | 0.123 | 1.311 | 0.020 | n/a |
| Northwestern Great Plains*, Wyoming Basin* | July 1 -Sept. 30 | 0.124 | 1.358 | 0.076 | n/a |

*Response variables for these ecoregions are the Montana dissolved oxygen standards (per DEQ-7) rather than benthic algae criteria.

MT DEQ has developed methods for determining a stream's compliance for purposes of 303(d) listing. Detailed recommendations concerning sampling design, sample-size minima, forms of the null hypothesis, etc. are provided in Appendix H of the technical report "Updated Statistical Analyses of Water Quality Data, Compliance Tools, and Changepoint Assessment for Montana Rivers and Streams (Varghese *et al.* , 2008), available at the website shown above. Key points from the report will be outlined below.

It is recommended that 12 independent samples for each nutrient of concern be collected within each stream segment in question, during the time period when the criteria apply. The nutrient samples should be temporally and spatially independent. Same-site sampling events should be separated by approximately one month to assure temporal independence. Spatial independence is more problematic, but it is suggested that these guidelines be followed:

- Sites (or very short reaches equivalent to sites) should be located a minimum of 1 mile apart along the stream segment.
- Sites may be placed < 1 mile apart on the stream segment **if** there is an active tributary confluencing with the segment between the two sites.
- Land use changes and land form changes should be considered and can be used to help identify additional sampling sites within the stream reach. See page 11-12 of DEQ (2005).

Stream benthic algae data should be collected at stream sites following MT DEQ SOPs (DEQ, 2008). However, twelve algae sampling events need not be undertaken; a single sampling event at each site is sufficient, although if time and money allow, multiple sampling events are better. I recommend that both Chl *a* and AFDW be measured, as benthic algae have different growth phases, some later phases being characterized by high AFDW:Chla ratios as the algae senesce. Measuring both AFDW and Chl *a* will assure that compliance can be checked against either biomass criterion. Each sampling event should be viewed on its own merits (i.e., do not average algae data across sites, or across time at a single site).

Analysis indicates that a 20% exceedence of a nutrient criterion (but *not* the algae biomass criteria) can occur without impacting the beneficial uses (Appendix H; Varghese *et al*., 2008); thus, a 20% allowable exceedence rate is incorporated into statistical testing procedures (more on this in a moment).

The nutrient data should be evaluated using two different statistical tests and, depending upon if the stream is currently considered impaired (or not), different forms of the null hypothesis are used. The conditions for the first statistical test (Exact Binomial Test) should be set such that alpha = 0.25, critical exceedence rate = 0.2 (20%, as discussed above), and the effect size set at 0.15. Given the fairly small sample size (12), these test conditions provide relatively balanced alpha and beta error. For a discussion on the merits of balancing alpha and beta error, see Mapstone (1995). The other test, the One Sample Student's t-test for the Mean, should have an alpha = 0.25, and it is also necessary to use the nutrient criterion concentration and also the nutrient data collected from the stream segment. Historic data can also be included in these tests; presumably data 5-10 years old or newer should be used.

The results from the two statistical tests, along with the results from the benthic algae sampling, are then considered together in a decision matrix (Table 2). In general, more emphasis is placed on the results from the Exact Binomial Test and the algae sampling than on the T-test. Some of the eight scenarios shown may be unlikely to arise, but all permutations are being presented at this point, until MT DEQ has more experience with using this decision matrix. Stream segments for which the decision is "Not in Compliance" can be considered to be exceeding the nutrient criteria.

Remember that the numeric recommendations shown in Table 1 have not been approved by the Montana Board of Environmental Review. They are the scientific and technical recommendations MT DEQ can currently offer as a direct interpretation of the narrative water quality standard found at ARM 17.30.637(1)(e).

Again, much more detail on the statistical tools, exceedence rate, sampling design, assumptions, etc. can be found in Appendix H of Varghese *et al.* (2008). Please do not hesitate to contact me with any questions you may have at (406) 444-0831, or msuplee@mt.gov.

Table 2. Decision rules for determining compliance with nutrient criteria, cold-water streams. For each statistical test, regardless of the form of the null hypothesis, PASS means the stream segment complies with the nutrient criterion, FAIL means the stream segment does not comply with the nutrient criterion.

| Scenario | Binomial Test | T-test | Benthic Algae* | **Resulting Decision** | Notes on Decision |
|---|---|---|---|---|---|
| 1 | PASS | PASS | ≤150 mg Chl*a* /$m^2$ or ≤36 g AFDW/$m^2$ | In Compliance | All indications show that the stream is in compliance. |
| 2 | PASS | FAIL | ≤150 mg Chl*a* /$m^2$ or ≤36 g AFDW/$m^2$ | In Compliance | Suggests pulsed nutrient loads occur but are not resulting in elevated benthic algae biomass. |
| 3 | FAIL | PASS | ≤150 mg Chl*a* /$m^2$ or ≤36 g AFDW/$m^2$ | Borderline | Likely that segment sometimes has high benthic algae biomass, but the timing of the algae sampling may have missed high levels. Borderline case; compliance or non-compliance may be equally justifiable; use other accompanying data (e.g., biometrics) to confirm decision. OR, further sample algae & nutrients. |
| 4 | FAIL | FAIL | ≤150 mg Chl*a* /$m^2$ or ≤36 g AFDW/$m^2$ | Not in Compliance | Likely that segment has high benthic algae biomass, but the timing of the algae sampling may have missed the high levels. **Further algae sampling may be justified.** |
| 5 | PASS | PASS | ≥150 mg Chl*a* /$m^2$ or ≥36 g AFDW/$m^2$ | Not in Compliance | Algae may be taking up nutrients and leading to low instream nutrient concentrations with concurrent high benthic algae biomass. |
| 6 | PASS | FAIL | ≥150 mg Chl*a* /$m^2$ or ≥36 g AFDW/$m^2$ | Not in Compliance | Non-compliance with the T-test suggests that pulsed nutrient loads are allowing high algae biomass to be maintained via luxury uptake. |
| 7 | FAIL | PASS | ≥150 mg Chl*a* /$m^2$ or ≥36 g AFDW/$m^2$ | Not in Compliance | Suggests sustained nutrient values near the standard but not necessarily pulsed nutrient loading. |
| 8 | FAIL | FAIL | ≥150 mg Chl*a* /$m^2$ or ≥36 g AFDW/$m^2$ | Not in Compliance | All indicators show that the stream is not in compliance. |

* Benthic algae biomass collected and summarized as per DEQ SOPs, for a single site (short reach), during any given sampling event. Unlike nutrient samples, *do not* average together algae biomass results from different sites (short reaches) across the stream segment. Consider each site (short reach) on its own merits.

**REFERENCE LIST**


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